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(54) **KEYBOARD MODULE AND DISPLAY SYSTEM**

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G06F 3/042 (2006.01)
G06F 3/0354 (2013.01)

(52) **U.S. Cl.**
CPC ***G06F 3/021*** (2013.01); ***G06F 3/02*** (2013.01); ***G06F 3/03547*** (2013.01); ***G06F 3/042*** (2013.01)

(58) **Field of Classification Search**
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USPC 345/168–172
See application file for complete search history.

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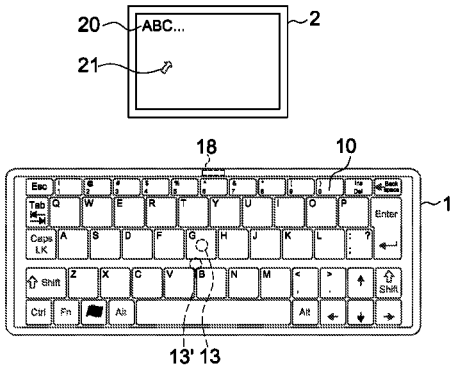
(57) **ABSTRACT**

There is provided a keyboard module including a plurality of keyboard keys, an optical finger mouse and a transmission interface. The keyboard keys are configured to trigger a digital signal. The optical finger mouse is configured to detect a physiological characteristic and a displacement. The transmission interface is configured to send the digital signal, the physiological characteristic and the displacement to a display device. There is further provided a display system.

17 Claims, 5 Drawing Sheets



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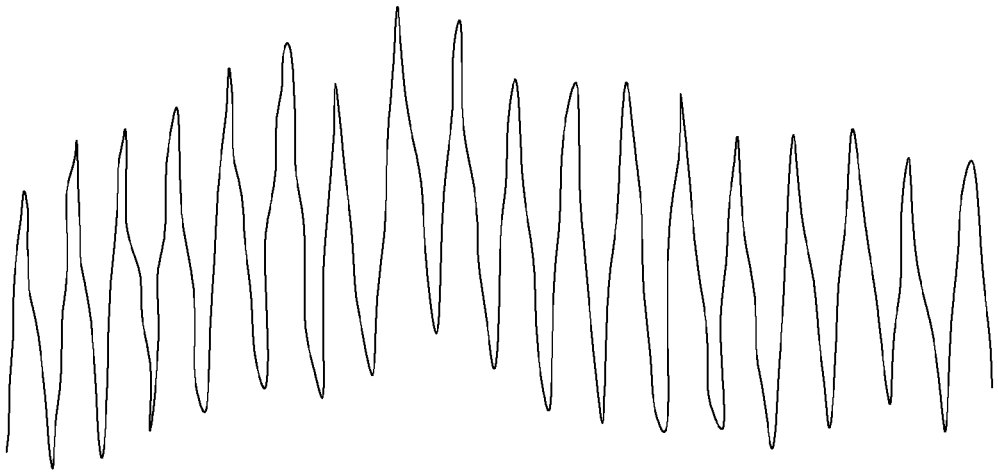

FIG. 1

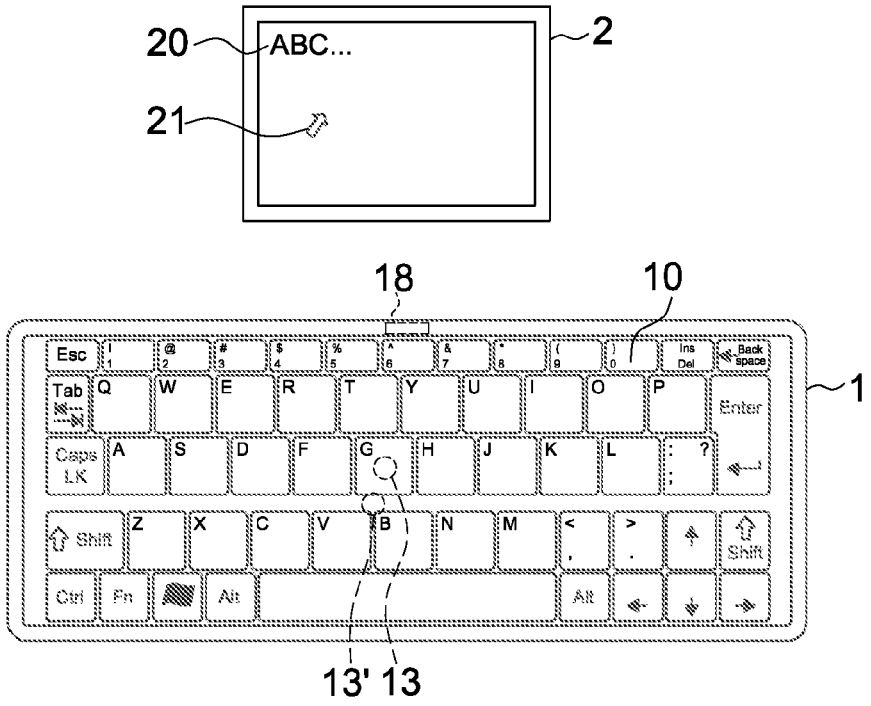

FIG. 2A

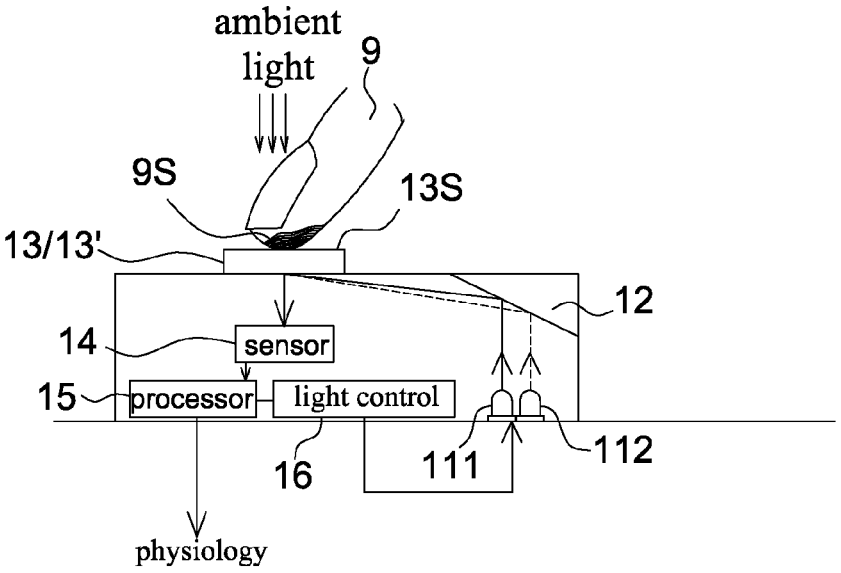
ambient
light
9
9S
13S
13/13'
12
14
sensor
15
processor
light control
16
111
112
physiology

FIG. 2B

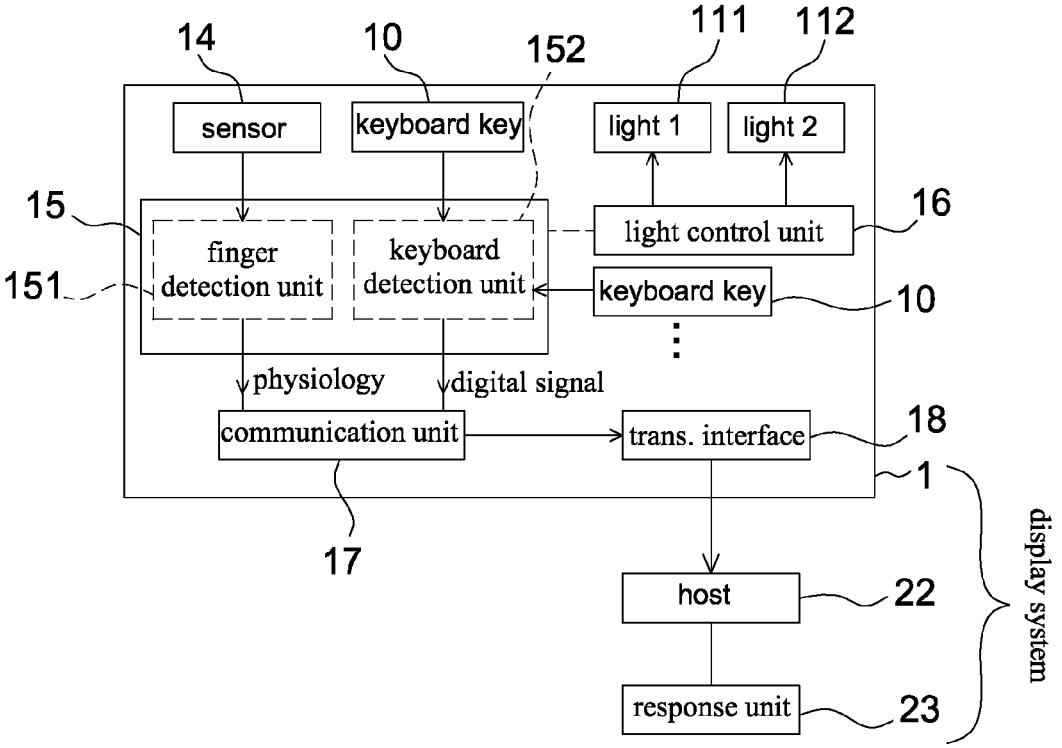
14
10
152
111
112
sensor
keyboard key
light 1
light 2
15
16
finger
detection unit
keyboard
detection unit
light control unit
151
keyboard key
10
physiology
digital signal
communication unit
trans. interface
18
1
17
host
22
response unit
23
display system

FIG. 2C

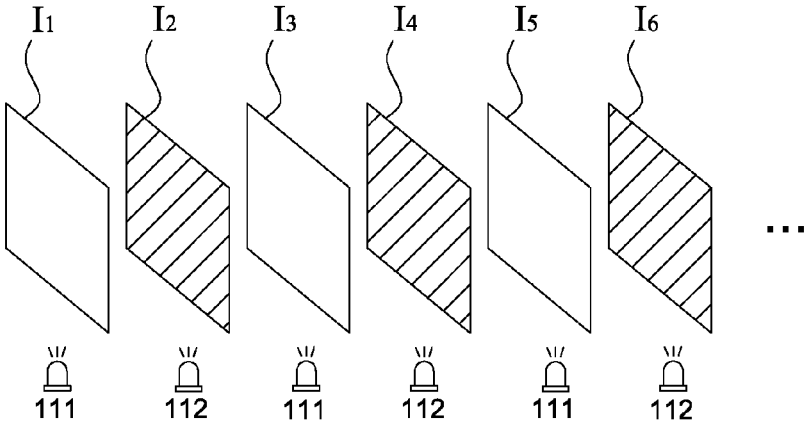

FIG. 3

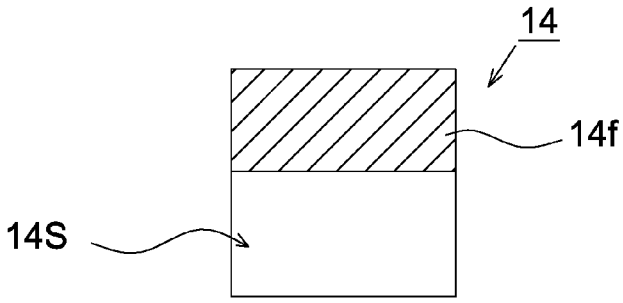

FIG. 4

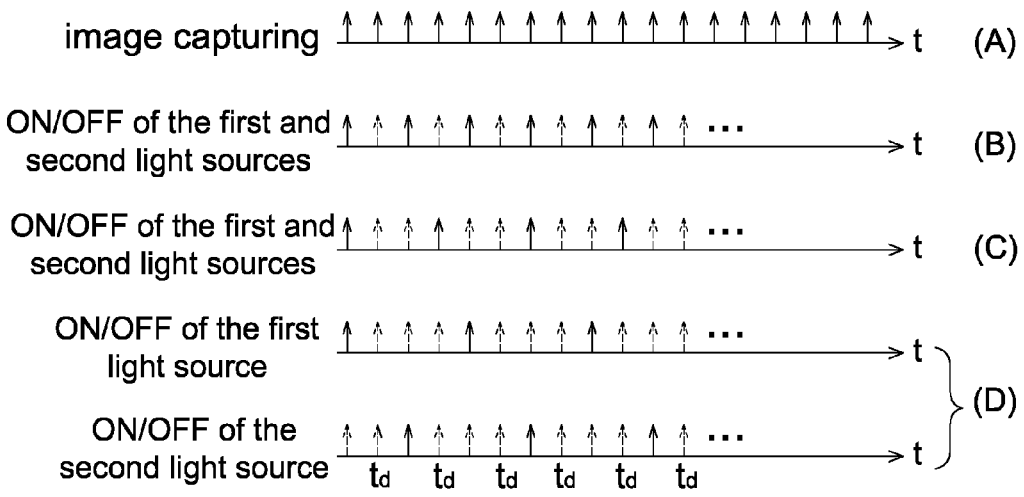

FIG. 5

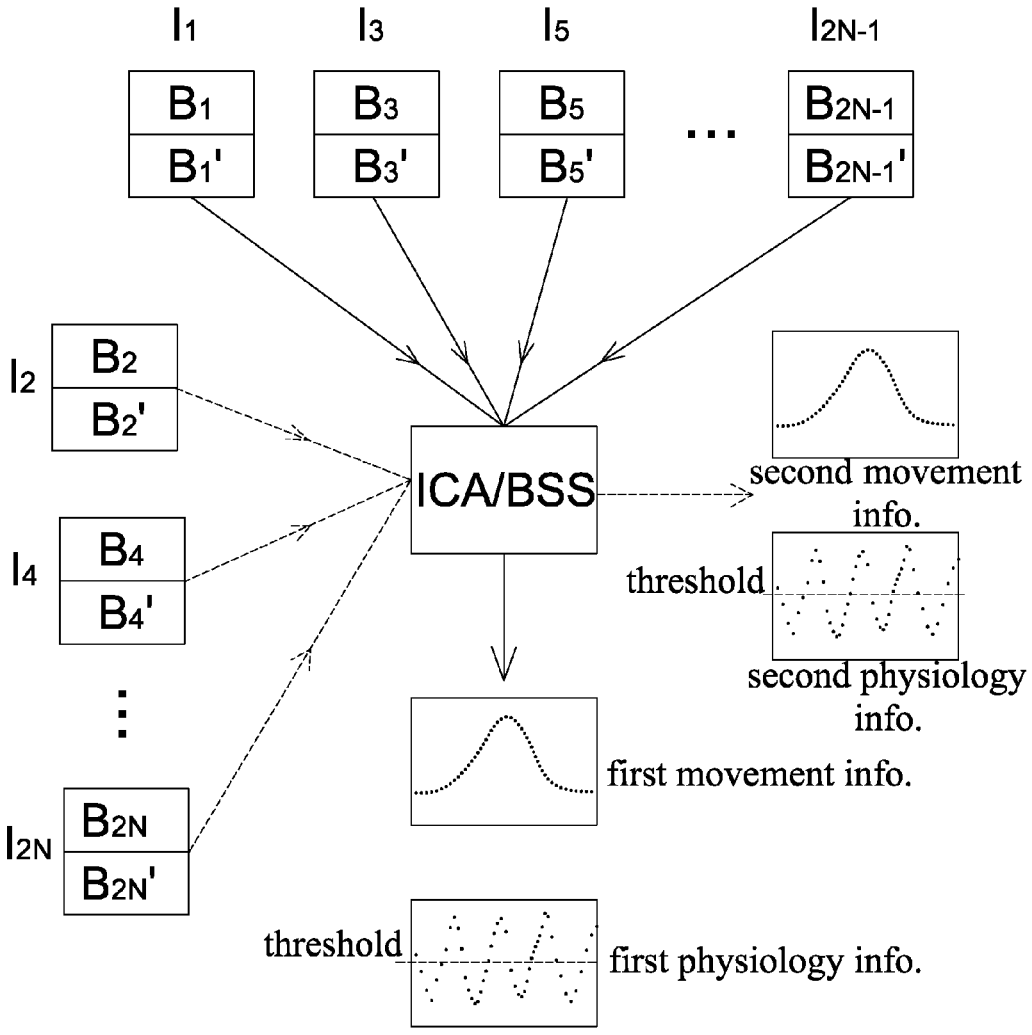
I1
I3
I5
I2N-1
B1
B1'
B3
B3'
B5
B5'
...
B2N-1
B2N-1'
I2
B2
B2'
ICA/BSS
second movement info.
threshold
second physiology info.
I4
B4
B4'
first movement info.
I2N
B2N
B2N'
threshold
first physiology info.

FIG. 6

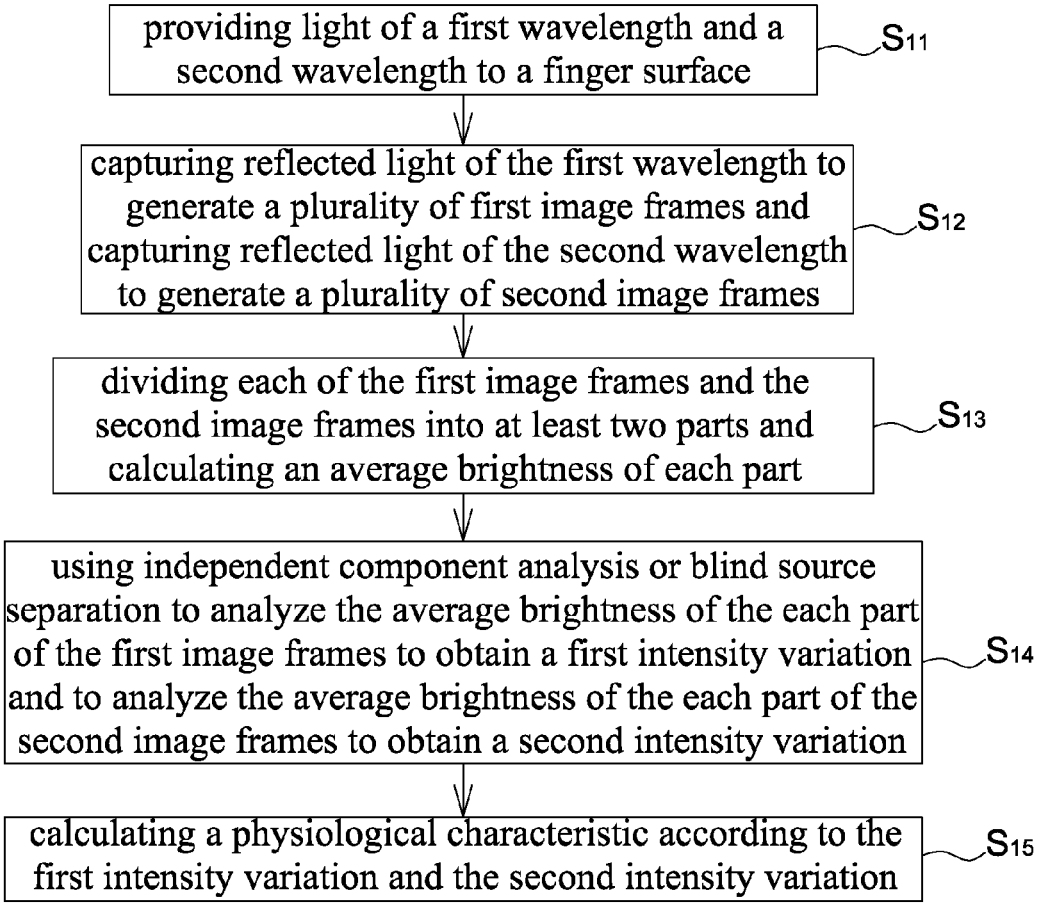
providing light of a first wavelength and a second wavelength to a finger surface
S11
capturing reflected light of the first wavelength to generate a plurality of first image frames and capturing reflected light of the second wavelength to generate a plurality of second image frames
S12
dividing each of the first image frames and the second image frames into at least two parts and calculating an average brightness of each part
S13
using independent component analysis or blind source separation to analyze the average brightness of the each part of the first image frames to obtain a first intensity variation and to analyze the average brightness of the each part of the second image frames to obtain a second intensity variation
S14
calculating a physiological characteristic according to the first intensity variation and the second intensity variation
S15

FIG. 7

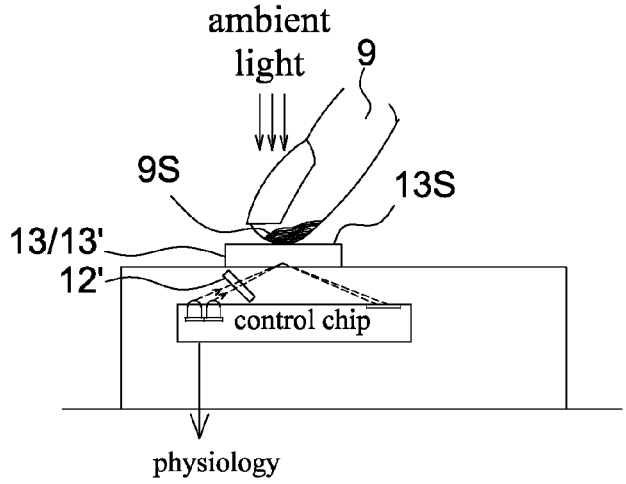
ambient light
9
9S
13S
13/13'
12'
control chip
physiology

FIG. 8

KEYBOARD MODULE AND DISPLAY SYSTEM

CROSS REFERENCE TO RELATED APPLICATION

This application claims the priority benefit of Taiwan Patent Application Serial Number 100142002, filed on Nov. 17, 2011, the full disclosure of which is incorporated herein by reference.

BACKGROUND

1. Field of the Disclosure

This disclosure generally relates to a human interface system and, more particularly, to a keyboard module and a display system that have the function of detecting physiological characteristics of a user.

2. Description of the Related Art

As the optical finger mouse has a relatively small size, it is suitable for being applied to portable electronic devices. A conventional optical finger mouse can be used to detect an intensity variation of reflected light from a finger surface of a user so as to accordingly identify a finger contact status and a finger displacement with respect to a touch surface. However, with the development of industry, users spend more and more time on utilizing various portable electronic devices that puts a lot of stress on their bodies. Therefore, if a portable electronic device also has the function of detecting physiological characteristics of a user and is able to give a warning when necessary, the overuse of the portable electronic devices can then be avoided.

Conventional pulse oximeters utilize a noninvasive method to monitor the blood oxygenation and the heart rate of a user. A conventional pulse oximeter generally emits a red light beam (wavelength of about 660 nm) and an infrared light beam (wavelength of about 910 nm) to penetrate a part of the human body and detects an intensity variation of the penetrating light based on the feature that the oxyhemoglobin and the deoxyhemoglobin have different absorptivities in particular spectrum, e.g. referring to U.S. Pat. No. 7,072,701 and entitled "Method for spectrophotometric blood oxygenation monitoring". After the intensity variation of the penetrating light of the two wavelengths is detected, the blood oxygenation can be calculated according to equation (1):

$$\text{Oxygen saturation}=100\%\times[HbO_2]/([HbO_2]+[Hb]) \quad (1)$$

wherein $[HbO_2]$ is an oxyhemoglobin concentration; and [Hb] is a deoxyhemoglobin concentration.

Generally, the intensity variation of the penetrating light of the two wavelengths detected by a pulse oximeter is similar to FIG. **1**. This is because blood vessels will expand and contract with heartbeats such that the blood volume that the light beams pass through will change to accordingly change the ratio of light energy being absorbed. Therefore, the absorptivity of blood of different light spectra can be calculated according to the intensity information changing continuously so as to calculate the physiology information, e.g. the oxyhemoglobin and deoxyhemoglobin concentration, respectively. Finally, the blood oxygenation can be calculated according to equation (1).

However, as conventional pulse oximeters detect the intensity variation of the penetrating light, different intensity signals will be detected by detecting different parts of the human body. In addition, when the part of the human body being detected has a movement, a disturbed signal can be detected such that it is not possible to calculate correct physiology information. Therefore, conventional pulse oximeters cannot be applied to electronic devices operated in a moving state.

Accordingly, the present disclosure provides a keyboard module and a display system capable of detecting physiological characteristics of a user, wherein the signal noise caused by the finger movement can be eliminated by the keyboard module in detecting the physiological characteristics.

SUMMARY

It is an object of the present disclosure to provide a keyboard module and a display system in which the keyboard module may detect a finger contact status, a finger displacement and a physiological characteristic of a user by analyzing reflected light from a finger, and generate a digital signal according to an operating state of at least one keyboard key to accordingly control a display device to perform a corresponding operation.

It is another object of the present disclosure to provide a control chip that may detect a finger contact status, a finger displacement and a physiological characteristic of a user by analyzing reflected light from a finger, and generate a digital signal according to an operating state of at least one keyboard key so as to output the encoded, sequenced and/or compressed finger information, physiology information and digital signal information.

It is another object of the present disclosure to provide a keyboard module and a display system that may detect a finger contact status, a finger displacement and a physiological characteristic of a user, and has a mechanism of eliminating the interference from ambient light sources.

It is another object of the present disclosure to provide a keyboard module and a display system that may detect a finger contact status, a finger displacement and a physiological characteristic of a user, and has the denoising mechanism.

It is another object of the present disclosure to provide a keyboard module and a display system that may detect a finger contact status, a finger displacement and a physiological characteristic of a user, and may enter a sleep mode after idling for a predetermined time period.

It is another object of the present disclosure to provide a keyboard module and a display system that may detect a finger contact status, a finger displacement and a physiological characteristic of a user, and the physiological characteristic may be abandoned if the finger displacement is too large.

The present disclosure provides a keyboard module configured to detect and output a physiological characteristic of a finger and a digital signal. The keyboard module includes a plurality of keyboard keys, a first light source, a second light source, a light control unit, at least one image sensor and a processing unit. The first light source provides light of a first wavelength to the finger. The second light source provides light of a second wavelength to the finger. The light control unit is configured to control on-states of the first light source and the second light source. The image sensor receives reflected light from the finger at a sampling frequency to generate a plurality of first image frames corresponding to the on-states of the first light source and a plurality of second image frames corresponding to the on-states of the second light source. The processing unit is configured to calculate the physiological characteristic according to the first image frames and the second image

frames, and to generate the digital signal according to an operating state of the keyboard keys.

The present disclosure further provides a keyboard module for being operated by a user. The keyboard module includes a plurality of keyboard keys, an optical finger mouse, a communication unit and a transmission interface. The keyboard keys are configured to trigger a digital signal. The optical finger mouse is configured to detect a physiological characteristic of the user and a finger displacement. The communication unit is configured to perform at least one of an encoding process, a sequential process and a compressing process on the digital signal, the physiological characteristic and the finger displacement. The transmission interface is configured to output the processed digital signal, the processed physiological characteristic and the processed finger displacement.

The present disclosure further provides a display system includes a display device and a keyboard module. The display device is configured to display images. The keyboard module is configured to output a digital signal and a physiological characteristic to the display device so as to control the display device to update the images being displayed according to the digital signal and to display the physiological characteristic.

In the embodiments of the present disclosure, each of the first image frames is divided into at least two parts and an average brightness of each part is calculated; and the average brightness of the each part of the first image frames is calculated to obtain a first intensity variation using independent component analysis or blind source separation. Each of the second image frames is divided into at least two parts and an average brightness of each part is calculated; and the average brightness of the each part of the second image frames is calculated to obtain a second intensity variation using independent component analysis or blind source separation. The physiological characteristic is calculated according to the first intensity variation and the second intensity variation.

In the keyboard module and the display system of the present disclosure, the physiological characteristic may include a blood oxygenation and a heart rate. In the present disclosure, the movement informant and the physiology information are separated by means of independent component analysis (ICA) or blind source separation (BSS) so as to effectively eliminate the signal noise caused by the finger movement.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, advantages, and novel features of the present disclosure will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings.

FIG. **1** shows a schematic diagram of an intensity variation of the penetrating light detected by pulse oximeters.

FIG. **2**A shows a schematic diagram of the display system according to an embodiment of the present disclosure.

FIG. **2**B shows a schematic diagram of the optical finger mouse of the keyboard module according to an embodiment of the present disclosure.

FIG. **2**C shows a schematic block diagram of the display system according to an embodiment of the present disclosure.

FIG. **3** shows a schematic diagram of the image frames captured by the image sensor of the optical finger mouse of the keyboard module according to the embodiment of the present disclosure.

FIG. **4** shows a schematic diagram of the image sensor of the optical finger mouse of the keyboard module according to the embodiment of the present disclosure, wherein an optical filter is disposed in front of a part of a sensing surface thereof.

FIG. **5** shows a schematic diagram of the image capturing of the image sensor and the ON/OFF of the light source in the optical finger mouse of the keyboard module according to the embodiment of the present disclosure.

FIG. **6** shows a schematic diagram of separating the movement information and the physiology information by the processing unit of the keyboard module according to the embodiment of the present disclosure.

FIG. **7** shows a flow chart of the physiology detection method according to an embodiment of the present disclosure.

FIG. **8** shows a schematic diagram of the optical finger mouse of the keyboard module according to another embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENT

It should be noted that, wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

Please refer to FIG. **2**A, it shows a schematic diagram of the display system according to an embodiment of the present disclosure. The display system includes a keyboard module **1** and a display device **2**. The display device **2** may be a television, a projection screen, a game machine screen, a computer screen or other display devices for displaying images. The keyboard module **1** is configured to control the display device **2** to update images being displayed or display a physiological characteristic, wherein the keyboard module **1** may be wired or wirelessly coupled to the display device **2**. The keyboard module **1** is configured to detect and output a physiological characteristic, a contact status, a finger displacement and a digital signal to the display device **2**.

The keyboard module **1** includes a plurality of keyboard keys **10**, an optical finger mouse and a transmission interface **18**, wherein the optical finger mouse includes a touch member for a finger to operate thereon, and the touch member may be combined with one of the keyboard keys **10** (e.g. indicated by a reference number **13**) or separated from the keyboard keys **10** (e.g. indicated by a reference number **13'**). The keyboard keys **10** are configured to trigger a digital signal according to an operating state (e.g. a pressing state) of a user, e.g. generating the digital signal associated with different resistances, voltage values or oscillation frequencies by pressing at least one keyboard key, wherein the digital signal may be related to a text **20**, a number, a symbol and/or a control signal that is outputted by a general keyboard. The optical finger mouse is configured to detect a contact status of the finger of a user, a displacement and a physiological characteristic of the user, wherein the physiological characteristic may include a blood oxygenation and a heart rate. In this embodiment, the optical finger mouse starts to detect the displacement and the physiological characteristic when identifying that the contact status is a touch state. The transmission interface **18** is configured to wired or wirelessly transmit the digital signal, contact status, displacement and physiological characteristic to the display device **2** such that the display device **2** may update images being displayed according to the digital signal and display the displacement and the physiological characteristic.

Please refer to FIG. **2**B, it shows a schematic diagram of the optical finger mouse of the keyboard module **1** according to an embodiment of the present disclosure. The optical finger mouse includes two light sources **111**-**112**, a light guide **12** (a number of the light guide herein is only exemplary), a touch member **13**/**13'**, an image sensor **14**, a processing unit **15** and a light control unit **16**. It should be mentioned that the spatial relationship between every component in FIG. **2**B is only exemplary and not to limit the present disclosure. The light sources **111**-**112** may be light emitting diodes or laser diodes and are configured to respectively emit light of different wavelengths to a finger surface **9**S. Preferably, said different wavelengths are the two wavelengths used in conventional pulse oximeters, e.g. red light of wavelength about 660 nm and infrared light of wavelength about 905, 910 or 940 nm. It is appreciated that the wavelengths mentioned herein are the center wavelength of respective illumination spectrum of the light sources **111**-**112**.

The light guide **12** is configured to direct the light emitted by the light sources **111** and **112** to the touch member **13**, wherein the structure, the number and the light guiding mechanism of the light guide **12** do not have any limitation as long as the light guide **12** is able to direct the light emitted by the light sources **111** and **112** to the touch member **13**. In other embodiments, if the light emitted from the light sources **111**-**112** can directly impinge on the touch member **13**, the light guide **12** may not be implemented.

The touch member **13** has a touch surface **13**S for the finger **9** to operate thereon, and the touch member **13** is preferably transparent to the light emitted by the light sources **111** and **112**, wherein when the touch member **13** is combined with a keyboard key **10**, the keyboard key **10** is preferably also transparent to the light emitted by the light sources **111** and **112**. When the finger **9** approaches or touches the touch surface **13**S of the touch member **13**, the light emitted by the light sources **111** and **112** is reflected. It is appreciated that an area of the touch surface **13**S may be larger or smaller than that of the finger surface **9**S.

The image sensor **14** receives, with a sampling parameter, reflected light from the touch member **13** (more specifically from the finger surface **9**S) to generate a plurality of image frames, which may have a size of 16×16, wherein the sampling parameter may include an exposure time and an image gain, e.g. an analog gain or a digital gain, but not limited thereto. The image sensor **14** is preferably an active matrix sensor, e.g. a CMOS image sensor.

The processing unit **15** generates a digital signal corresponding to an operating state of the keyboard keys **10**, and detects a contact status and a displacement of the finger **9** with respect to the touch surface **13**S and a physiological characteristic of the user according to a plurality of image frames outputted by the image sensor **14**. The digital signal, contact status, displacement and physiological characteristic obtained by the processing unit **15** may be wired or wirelessly sent to a display device having at least one response unit for displaying or corresponding control, wherein the response unit may be a monitor, a lamp device, a seven-segment display and/or a sound device. The display device may be a portable electronic device or a home appliance.

The light control unit **16** is coupled to the processing unit **15** and configured to control on-states and off-states of the light sources **111**-**112** corresponding to the image capturing of the image sensor **14**, and details thereof will be described hereinafter.

In this embodiment, the light sources **111** and **112**, the image sensor **14**, the processing unit **15** and the light control unit **16** are served as an optical finger mouse configured to detect and output a contact status, a displacement and a physiological characteristic of the finger **9**.

Please refer to FIGS. **2**A to **2**C, FIG. **2**C shows a schematic block diagram of the display system according to an embodiment of the present disclosure. The keyboard module **1** includes a plurality of keyboard keys **10**, a first light source **111**, a second light source **112**, the image sensor **14**, the processing unit **15**, the light control unit **16**, a communication unit **17** and a transmission interface **18**, wherein a display system may be composed of the keyboard module **1** and a host **22** as well as a response unit **23**. Because the processing unit **15** has multifunction, the processing unit **15** may further include a finger detection unit **151** configured to detect the contact status and the finger displacement of the finger **9** with respect to the touch surface **13**S and the physiological characteristic, and include a keyboard detection unit **152** configured to generate and output the digital signal according to the operating state (e.g. the pressing state) of the keyboard keys **10**. That is, the processing unit **15** may be a single element or composed of two elements.

The first light source **111** may emit red light of wavelength about 660 nm to the finger **9**, and the second light source **112** may emit infrared light of wavelength about 905, 910 or 940 nm to the finger **9**. Broadly speaking, the first light source **111** and the second light source **112** may respectively emit light of the two wavelengths used in conventional pulse oximeters. The light control unit **16** controls the first light source **111** and the second light source **112** to emit light. The image sensor **14** receives reflected light associated with the first light source **111** and the second light source **112** from the finger surface **9**S. The communication unit **17** is configured to perform at least one of an encoding process, a sequential process and a compressing process on the digital signal, contact status, displacement and physiological characteristic obtained by the processing unit **15** and send processed results to the transmission interface **18** for transmission The transmission interface **18** may be a PS2 interface, USB interface, Bluetooth interface or other transmission interfaces suitable for the keyboard and is configured to wired or wirelessly transmit the encoded, sequenced and/or compressed digital signal, contact status, displacement and physiological characteristic to an external host **22**, wherein the wired and wireless communication techniques are well known and thus details thereof are not described herein. The host **22** may be coupled to the display device **2** having at least one response unit **23** and is configured to control the display device **2** to display and/or respond the received digital signal, contact status, displacement and physiological characteristic by means of the response unit **23**. The host **22** may be integrated in the response unit **23** to form a display device or separated from the response unit **23**.

The keyboard module **1** of the present disclosure may incorporate with a display device **2** having a response unit **23** such that a user may control a cursor shown on the response unit **23**, a software executed and images displayed using the keyboard module **1**, and the response unit **23** may give a warning when the physiological characteristic indicates that the user is in a fatigue or excitatory state (e.g. according to a value of the physiological characteristic), wherein the method of showing the physiological characteristic and the warning may be implemented by, for example, showing on a screen, representing by a lamp device or by sound controlled by a software. The display device **2** may switch screens, display symbols, update images, adjust display parameters according to the digital signal; may control the motion of a cursor according to the displacement; may show

the physiological characteristic and generate a warning state when the physiological characteristic exceeds a predetermined value, such as reducing the darkness of the screen, inserting an image object, playing a sound and so on.

In one embodiment, the keyboard module **1** may include two image sensors configured to detect light of two different wavelengths respectively emitted by the light sources **111** and **112** (i.e. the image sensor **14** is replaced by two image sensors), wherein an optical bandpass filter may be integrated on one or two of the image sensors in order to select the desired spectrum.

As the method of generating the digital signal by the processing unit **15** (or the keyboard detection unit **152**) according to the keyboard keys **10** are well known, details thereof are not described herein. Only the methods of calculating the contact status, finger displacement and physiological characteristic by the processing unit **15** (or the finger detection unit **151**) will be described hereinafter; that is, only the operation of the optical finger mouse formed by the light sources **111** and **112**, the image sensor **14**, the processing unit **15** (or the finger detection unit **151**) and the light control unit **16** will be described hereinafter.

Sampling Mechanism

The optical finger mouse of the present disclosure utilizes two light sources **111** and **112** and may perform two functions simultaneously, wherein the function of detecting the contact status and displacement may use the image frames associated with any wavelength without limitation, but the function of detecting the physiological characteristic needs to be respectively performed corresponding to the image frames of different wavelengths. First, the sampling mechanism of the image frames in the present disclosure is illustrated hereinafter.

In one embodiment, the light control unit **16** controls the first light source **111** and the second light source **112** to turn on alternatively. The image sensor **14** captures image frames at a high and fixed sampling frequency (e.g. 3,000 frames/sec) and synchronizing to the turning on (i.e. on-states) of the first light source **111** or the second light source **112**, and outputs a plurality of image frames I_1 to I_6 . . . as shown in FIG. **3** to the processing unit **15** (or the finger detection unit **151**), wherein the image frames I_1 to I_6 . . . include first image frames I_1, I_3, I_5 . . . corresponding to the on-states of the first light source **111** and second image frames I_2, I_4, I_6 . . . corresponding to the on-states of the second light source **112**.

The processing unit **15** may identify a contact status and calculate a displacement according to the first and second image frames I_1 to I_6 . . . , e.g. identifying whether the finger **9** approaches or touches the touch surface **13**S according to a comparison result of comparing a brightness value of the first and second image frames with at least one brightness threshold, wherein when the brightness value of the image frames is larger or smaller than the brightness threshold, a touch state is entered. After entering the touch state, the processing unit **15** may calculate the displacement according to the correlation between two first image frames, between one first image frame and one second image frame, or between two second image frames. It should be mentioned that the identification of the contact status and the calculation of the displacement in the present disclosure need to use the image frames associated with the reflected light of two different wavelengths and thus are different from conventional navigation devices.

The processing unit **15** may calculate an intensity variation of first image frame according to the first image frames I_1, I_3, I_5 . . . , and calculate an intensity variation of second image frame according to the second image frames I_2, I_4, I_6 . . . (described later), and accordingly calculate the absorptivity of blood in two spectra so as to obtain [HbO_2] and [Hb]. Finally, the blood oxygenation may be calculated according to equation (1), and the heart rate may also be calculated according to a comparison result of comparing the intensity variation of first image frame and/or the intensity variation of second image frame with at least one pulse threshold.

In another embodiment, the light control unit **16** controls the first light source **111** and the second light source **112** to turn on simultaneously and synchronizing to the image capturing of the image sensor **14**; that is, the image sensor **14** may receive reflected light of two wavelengths simultaneously. Therefore, in this embodiment an optical filter **14***f* is further disposed in front of at least a part of a sensing surface **14**S of the image sensor **14** as shown in FIG. **4**, wherein the optical filter **14***f* may be an optical bandpass filter to allow the part of the sensing surface **14**S behind the optical filter **14***f* to only receive the spectrum of light of the first light source **111** or the second light source **112** such that the processing unit **15** may distinguish the first image frame (i.e. the part of the image frame associated with the first light source **111**) and the second image frame (i.e. the part of the image frame associated with the second light source **112**). It is appreciated that in the present disclosure the position and the area of the optical filter **14***f* are not limited to those shown in FIG. **4**.

In this manner, the processing unit **15** may also calculate a contact status and a displacement according to the first and second image frames I_1 to I_6 . . . . The processing unit **15** may also calculate the intensity variation of first image frame according to the first image frames I_1, I_3, I_5 . . . , calculate the intensity variation of second image frame according to the second image frames I_2, I_4, I_6 . . . , and calculate at least one of the blood oxygenation and the heart rate according to the two intensity variations.

It is appreciated that as the sensing efficiency of the image sensor **14** toward light of different wavelengths may be different or the illumination brightness values of the first light source **111** and the second light source **112** may not be identical, the brightness value of the image frames captured by the image sensor **14** may be previously adjusted (e.g. by adjusting the sampling parameter, such as an exposure time and an image gain, of the image frames corresponding to different wavelengths) before the shipment of the keyboard module **1** such that the image frames initially outputted by the image sensor **14** may have substantially identical brightness values so as to eliminate the possibility of error.

In this embodiment, the light control unit **16** controls the first light source **111** and the second light source **112** such that the image sensor **14** captures reflected light from the finger **9** at a sampling frequency to generate a plurality of first image frames corresponding to on-states of the first light source **111** and a plurality of second image frames corresponding to on-states of the second light source **112**. The processing unit **15** calculates the contact status, finger displacement and physiological characteristic according to the first image frames and the second image frames.

Mechanism of Eliminating Ambient Light Interference

In FIG. **2**B, as the touch member **13** and the finger **9** are light transmissive, the ambient light outside the keyboard module **1** can penetrate the finger **9** and the touch member **13** (**13'**) and then be received by the image sensor **14** to degrade the image quality of the image frames captured thereby. In the present disclosure, the light control unit **16**

may control the first light source **111** and the second light source **112** to turn off (the off-state) in predetermined time intervals.

For example please refer to FIG. **5**, it shows a schematic diagram of the image capturing of the image sensor **14** and the ON/OFF of the first light source **111** and the second light source **112**, wherein in FIGS. **5**(B)-**5**(D) solid arrows denote the on-states of the light sources (or the lighting at a first brightness value) and dashed arrows denote the off-states of the light sources (or the lighting at a second brightness value), and the second brightness value may be smaller than the first brightness value. FIG. **5**(A) shows that the image sensor **14** captures image frames at a fixed sampling frequency. FIG. **5**(B) shows that the first light source **111** and the second light source **112** are alternatively turned on and turned off at the same time, and thus the image sensor **14** may alternatively capture bright image frames (i.e. corresponding to the on-states or the first brightness value of the light sources) and dark image frames (i.e. corresponding to the off-states or the second brightness value of the light sources). FIG. **5**(C) shows that the first light source **111** and the second light source **112** are simultaneously turned on once after being turned off two image periods, and this case is generally for a lower displacement of the finger **9**. As mentioned above, when the first light source **111** and the second light source **112** are turned on simultaneously, e.g. FIGS. **5**(B) and **5**(C), the image sensor **14** further includes an optical filter **14***f* (as shown in FIG. **4**) for spatially distinguishing the image frame associated with different light sources such that one part of the image sensor **14** may sense reflected light associated with the first light source **111** and the other part thereof may sense reflected light associated with the second light source **112**.

When the finger **9** touches or approaches the touch surface **13**S, the bright image frames, which are associated with the on-states of the light sources, include components of (reflected light from finger+stray light+ambient light), and the dark image frames, which are associated with the off-states of the light sources, include only the component of (ambient light). Therefore, if a dark image frame is subtracted from a bright image frame, the interference from the ambient light can be effectively eliminated. The processing unit **15** may calculate the contact status, finger displacement and physiological characteristic according to differential images between the bright image frames and the dark image frames.

Please refer to FIG. **5**(D), it shows an embodiment in which the first light source **111** and the second light source **112** are turned on alternatively. In this embodiment, in order to allow the image sensor **14** to be able to capture dark image frames, the light control unit **16** controls the first light source **111** and the second light source **112** to alternatively turn on every other image frame, e.g. the two light sources are both turned off at time t_d in FIG. **5**(D). Accordingly, the processing unit **15** may calculate a differential first image (i.e. bright first image frame−dark image frame) and a differential second image (i.e. bright second image frame−dark image frame), and calculate the contact status, finger displacement and physiological characteristic according to the differential first and second images. As mentioned above, if the first light source **111** and the second light source **112** are turned on alternatively, the image sensor **14** temporally distinguishes the image frames associated with different light sources.

In this embodiment, the light control unit **16** controls the first light source **111** and the second light source **112** to turn on simultaneously or alternatively and the image sensor **14** is able to capture dark image frames when both the light sources are turned off. The interference from ambient light is eliminated by calculating a difference between the bright image frame and the dark image frame. It is appreciated that the on-states and the off-states of each light source shown in FIG. **5** are only exemplary and not to limit the present disclosure.

Denoising Mechanism

As the image frames captured by the image sensor **14** generally include noise which is randomly distributed in the image frames being captured. Therefore, in the present disclosure it is able to calculate a sum of M image frames to increase the signal-to-noise ratio (SNR) thereby improving the calculation accuracy of the physiological characteristic. For example, it is able to calculate a sum of 10 image frames and two groups of 10 image frames may have partially repeated image frames or totally different 10 image frames. It is appreciated that if the first light source **111** and the second light source **112** are turned on alternatively, the sum of image frames in this embodiment may be a sum of the first image frames (e.g. $I_1+I_3+I_5+\ldots$ as shown in FIG. **3**) and a sum of the second image frames (e.g. $I_2+I_4+I_6+\ldots$ as shown in FIG. **3**) since two intensity variations need to be calculated respectively. However, if the first light source **111** and the second light source **112** are turned on simultaneously, the sum of image frames in this embodiment is a sum of successive image frames (e.g. $I_1+I_2+I_3+I_4+I_5+I_6+\ldots$ as shown in FIG. **3**), and the two intensity variations may be spatially distinguished by post-processing. In addition, if the mechanism of eliminating ambient light interference described above is incorporated in this embodiment, the sum of image frames in this embodiment is a sum of the differential images; that is, the process of eliminating ambient light interference is performed and then the process of denoising is performed successively. In other embodiments, only one of the mechanism of eliminating ambient light interference and the denoising mechanism is performed.

As mentioned above, the image sensor **14** may capture image frames with different sampling parameters at different conditions, e.g. the image sensor **14** may have different absorption of light at different wavelengths. Therefore different sampling parameters, such as different exposure times and different image gains, may be used to make the first image frames and the second image frames have substantially identical initial brightness values in order to correctly perform the post-processing on the image frames; that is, the sampling parameters associated with the first image frames and the second image frames may be different. In the present disclosure, in order to eliminate the influence of different sampling parameters, every image frame or the sum of M image frames or the average of M image frames may be normalized by the sampling parameter, e.g. (a sum of M image frames/sampling parameter) or (an average of M image frames/sampling parameter), wherein M is a positive integer.

Calculating Physiological Characteristics

Corresponding to the on-states of different light sources, the image frames captured by the image sensor **14** may contain physiology information and finger movement information at the same time. Therefore, in the present disclosure the processing unit **15** (or the finger detection unit **151**) has to separate two types of information at first and then is able to calculate the physiological characteristic correctly. In the present disclosure, the processing unit **15** may separate the two types of information according to, for example, independent component analysis (ICA) or blind source separation (BSS).

Please refer to FIGS. **3** and **6**, taking the first image frames $I_1, I_3, I_5 \ldots$ shown in FIG. **3** as an example, each of the first

image frames (e.g. original first image frames or the first image frames processed by the mechanism of eliminating ambient light interference and/or normalizing mechanism) or each of the sum of a plurality of first image frames (e.g. a sum of M original first image frames or a sum of M first image frames processed by the mechanism of eliminating ambient light interference and/or normalizing mechanism) is divided into at least two parts and an average brightness of each part is calculated, e.g. the image frame I_1 is divided into two parts respectively having an average brightness B_1 and B_1'; the image frame I_3 is divided into two parts respectively having an average brightness B_3 and B_3'; . . . ; the image frame I_{2N-1} is divided into two parts respectively having an average brightness B_{2N-1} and B_{2N-1}', wherein the image frames may be divided into more than two parts in other embodiments. Next, a first movement informant and a first physiology information is separated from the divided image frames according to independent component analysis (ICA) or blind source separation (BSS) method as shown in FIG. **6**, and each of the information is shown as a curve of intensity variation. In the present disclosure the movement information is abandoned and the physiological characteristic is calculated only according to the physiology information (i.e. the intensity variation of image frame). It is appreciated that as the sampling frequency of the image sensor **14** is much higher than the heart rate, the separated physiology information is shown as a curve of the intensity variation in accordance with the pulse beating (i.e. similar to FIG. **1**), but the separated movement information is not limited to that shown in FIG. **6**. In addition, the two parts divided from the image frames are not necessary to be the upper and the lower parts of the image frames. In addition, as it is necessary to respectively calculate the physiology information associated with two different wavelengths, the aforementioned separation process is performed respectively on the first image frames I_1, I_3, I_5 . . . (i.e. corresponding to the on-state of the first light source) and the second image frames I_2, I_4, I_6 . . . (i.e. corresponding to the on-state of the second light source) such that second movement information and second physiology information can be retrieved from the second image frames I_2, I_4, I_6 . . . , wherein the second movement information is abandoned and the intensity variation of the second physiological information is kept. It should be mentioned that, if the information separation is performed on the sum or average of the image frames, each of I_1 to I_{2N-1} and I_2 to I_{2N} shown in FIG. **6** represents a sum or an average of M image frames or normalized results thereof.

It should be mentioned that the contact status and the displacement of the finger **9** are calculated by the processing unit **15** directly according to the original first image frames and second image frames without using the separated first and second movement information. The ICA and BSS methods are mainly configured to separate combined signals. When the separated movement information is abandoned, it is able to eliminate the signal noise caused by the finger movement.

In the present disclosure, the processing unit **15** further calculates a heart rate according to a comparison result of comparing at least one pulse threshold with a first intensity variation (i.e. the first physiology information) and/or a second intensity variation (i.e. the second physiology information).

Sleep Mode

The keyboard module **1** of the present disclosure may enter a sleep mode after idling for a predetermined time period. For example, when the processing unit **15** identifies that a finger **9** does not approach or touch the touch surface **13**S within the predetermined time period, the sleep mode is entered. In the sleep mode, the image capturing of the image sensor **14** and the lighting of the light sources **111** and **112** may be disabled.

Mechanism of Removing Physiological Characteristic

Although the processing unit **15** of the keyboard module **1** of the present disclosure may calculate the displacement and the physiological characteristic simultaneously, accurate physiological characteristics are preferably obtained when the displacement is relatively small. Therefore, in the present disclosure the processing unit **15** may previously identify whether the finger displacement is larger than a predetermined value (i.e. a displacement threshold). When the finger displacement is larger than the predetermined value, the image frames captured by the image sensor **14** are only used to calculate the displacement or to identify the contact status but not used to calculate the physiological characteristic; or even though the physiological characteristic is calculated, the physiological characteristic is directly abandoned without being processed by the communication unit **17** or transmitted by the transmission interface **18**. The predetermined value may be determined according to different applications, e.g. according the size of the sensing surface **13**S and/or the size of the searching block, but not limited thereto.

The physiology detection method of the keyboard module **1** according to reflected light from the finger surface **9**S includes the steps of: providing light of a first wavelength and a second wavelength to a finger surface (Step S_{11}); capturing reflected light of the first wavelength to generate a plurality of first image frames and capturing reflected light of the second wavelength to generate a plurality of second image frames (Step S_{12}); dividing each of the first image frames and the second image frames into at least two parts and calculating an average brightness of each part (Step S_{13}); using independent component analysis or blind source separation to analyze the average brightness of the each part of the first image frames to obtain a first intensity variation and to analyze the average brightness of the each part of the second image frames to obtain a second intensity variation (Step S_{14}); and calculating a physiological characteristic according to the first intensity variation and the second intensity variation (Step S_{15}). Details of every step have been described above and thus are not repeated herein.

In another embodiment, a part of or all of the light sources **111**-**112**, the image sensor **14**, the processing unit **15**, the light control unit **16**, the communication unit **17** and the transmission interface **18** may be manufactured as a control chip or a package as shown in FIG. **8**. The control chip or the package is configured to detect an operating state of the keyboard keys **10** and to detect a contact status, displacement and physiological characteristic of the finger **9**, and to output encoded, sequenced and/or compressed contact status, displacement, physiological characteristic and digital signal, wherein the methods of calculating the contact status, displacement and physiological characteristic have been described above and thus details thereof are not repeated herein. It is appreciated that the disposition of every element of the optical finger mouse shown in FIG. **8** is only exemplary and not to limit the present disclosure. In other embodiments, said compression process may be performed by an additional compression unit.

As mentioned above, the conventional keyboard module can not detect the physiological characteristic of a user and the method of calculating the blood oxygenation for pulse oximeters cannot be applied to a keyboard module since it

can not detect a moving object. Therefore, the present disclosure further provides a keyboard module and a display system (FIGS. **2**B to **2**C) wherein the keyboard module can detect both the finger information and the keyboard information, and control a display device to update images to be displayed according to the keyboard information and to display the finger information. The keyboard module in the embodiments of the present disclosure may detect a finger displacement and a physiological characteristic of a user simultaneously and may eliminate the signal noise caused by finger movement and the interference from ambient light sources, and further has the mechanisms of entering sleep mode and removing invalid physiology information.

Although the disclosure has been explained in relation to its preferred embodiment, it is not used to limit the disclosure. It is to be understood that many other possible modifications and variations can be made by those skilled in the art without departing from the spirit and scope of the disclosure as hereinafter claimed.

What is claimed is:

1. A keyboard module configured to detect and output a physiological characteristic of a user and a digital signal, the keyboard module comprising:

a plurality of keyboard keys;

a first light source configured to provide light of a first wavelength to a finger of the user;

a second light source configured to provide light of a second wavelength to the finger, wherein the second wavelength is different from the first wavelength;

a light control unit configured to control on-states of the first light source and the second light source;

at least one image sensor configured to receive reflected light from the finger at a sampling frequency to generate a plurality of first image frames corresponding to the on-states of the first light source and a plurality of second image frames corresponding to the on-states of the second light source; and

a processing unit configured to

alternatively compare a brightness value of one of the first image frames with at least one brightness threshold and compare a brightness value of one of the second image frames with the at least one brightness threshold to identify a contact status of the finger with the keyboard module before the contact status is identified as a touch state,

divide each of the first image frames into a first part and a second part and calculate an average brightness of each of the first part and the second part, wherein the second part is other than the first part,

analyze the average brightness of each of the first part and the second part of the first image frames to obtain a first intensity variation,

divide each of the second image frames into a third part and a fourth part and calculate an average brightness of each of the third part and the fourth part, wherein the fourth part is other than the third part,

analyze the average brightness of each of the third part and the fourth part of the second image frames to obtain a second intensity variation,

calculate the physiological characteristic according to the first intensity variation and the second intensity variation,

calculate a finger displacement of the finger with respect to the keyboard module according to one of the first image frames and one of the second image frames consecutively captured by the image sensor, and

generate the digital signal according to an operating state of the keyboard keys,

wherein the processing unit is configured to identify whether the finger displacement exceeds a displacement threshold, and when the finger displacement exceeds the displacement threshold, the calculated physiological characteristic is abandoned.

2. The keyboard module as claimed in claim **1**, wherein the processing unit is further configured to calculate a heart rate of the user according to a comparison result of comparing at least one pulse threshold with at least one of the first intensity variation and the second intensity variation.

3. The keyboard module as claimed in claim **1**, wherein the physiological characteristic comprises a blood oxygenation and a heart rate.

4. The keyboard module as claimed in claim **1**, wherein the processing unit is further configured to calculate another finger displacement according to two of the first image frames and according to two of the second image frames.

5. The keyboard module as claimed in claim **1**, wherein the light control unit is configured to alternatively enable the on-states of the first light source and the second light source such that the image sensor receives the reflected light associated with the first light source and the second light source alternatively.

6. The keyboard module as claimed in claim **1**, wherein the first light source, the second light source, the light control unit, the at least one image sensor and the processing unit are packaged as a control chip to output the physiological characteristic and the digital signal processed by at least one of an encoding process, a sequential process and a compressing process.

7. The keyboard module as claimed in claim **1**, further comprising a touch member for the finger to operate thereon, wherein the touch member is one of the keyboard keys or separated from the keyboard keys.

8. The keyboard module as claimed in claim **1**, wherein the processing unit is configured to calculate the physiological characteristic and the finger displacement after identifying that the contact status is the touch state.

9. A keyboard module for being operated by a user, the keyboard module comprising:

a plurality of keyboard keys configured to trigger a digital signal;

an optical finger mouse configured to detect a physiological characteristic of the user and a finger displacement of a finger of the user with respect to the optical finger mouse, the optical finger mouse comprising:

a first light source configured to provide light of a first wavelength to the finger;

a second light source configured to provide light of a second wavelength to the finger, wherein the second wavelength is different from the first wavelength;

at least one image sensor configured to receive reflected light from the finger to generate a plurality of first image frames corresponding to on-states of the first light source and a plurality of second image frames corresponding to on-states of the second light source; and

a processing unit configured to

alternatively compare a brightness value of one of the first image frames with at least one brightness threshold and compare a brightness value of one of the second image frames with the at least one brightness threshold to identify a contact status of the finger with the optical finger mouse before the contact status is identified as a touch state,

divide each of the first image frames into a first part and a second part and calculate an average brightness of each of the first part and the second part, wherein the second part is other than the first part,

analyze the average brightness of each of the first part and the second part of the first image frames to obtain a first intensity variation,

divide each of the second image frames into a third part and a fourth part and calculate an average brightness of each of the third part and the fourth part, wherein the fourth part is other than the third part,

analyze the average brightness of each of the third part and the fourth part of the second image frames to obtain a second intensity variation,

calculate the physiological characteristic according to the first intensity variation and the second intensity variation, and

calculate the finger displacement with respect to the optical finger mouse according to one of the first image frames and one of the second image frames consecutively captured by the image sensor;

a communication unit configured to perform at least one of an encoding process, a sequential process and a compressing process on the digital signal, the physiological characteristic and the finger displacement; and

a transmission interface configured to output the processed digital signal, the processed physiological characteristic and the processed finger displacement,

wherein the processing unit is configured to identify whether the finger displacement exceeds a displacement threshold, and when the finger displacement exceeds the displacement threshold, the calculated physiological characteristic is not processed by the communication unit or the processed physiological characteristic is not outputted by the transmission interface.

10. The keyboard module as claimed in claim **9**, wherein the optical finger mouse further comprises:

a light control unit configured to control the on-states of the first light source and the second light source.

11. The keyboard module as claimed in claim **9**, wherein the processing unit is further configured to calculate a heart rate of the user according to a comparison result of comparing at least one pulse threshold with at least one of the first intensity variation and the second intensity variation.

12. The keyboard module as claimed in claim **9**, wherein the processing unit is configured to calculate the physiological characteristic and the finger displacement after identifying that the contact status is the touch state.

13. A display system, comprising:

a display device configured to display images; and

a keyboard module configured to output a digital signal and a physiological characteristic of a user to the display device to control the display device to update the images being displayed according to the digital signal and to display the physiological characteristic, the keyboard module comprising:

a first light source configured to provide light of a first wavelength to a finger of the user;

a second light source configured to provide light of a second wavelength to the finger, wherein the second wavelength is different from the first wavelength;

at least one image sensor configured to receive reflected light from the finger to generate a plurality of first image frames corresponding to on-states of the first light source and a plurality of second image frames corresponding to on-states of the second light source; and

a processing unit configured to

alternatively compare a brightness value of one of the first image frames with at least one brightness threshold and compare a brightness value of one of the second image frames with the at least one brightness threshold to identify a contact status of the finger with the keyboard module before the contact status is identified as a touch state,

divide each of the first image frames into a first part and a second part and calculate an average brightness of each of the first part and the second part, wherein the second part is other than the first part,

analyze the average brightness of each of the first part and the second part of the first image frames to obtain a first intensity variation,

divide each of the second image frames into a third part and a fourth part and calculate an average brightness of each of the third part and the fourth part, wherein the fourth part is other than the third part,

analyze the average brightness of each of the third part and the fourth part of the second image frames to obtain a second intensity variation,

calculate the physiological characteristic according to the first intensity variation and the second intensity variation, and

calculate a finger displacement of the finger with respect to the keyboard module according to one of the first image frames and one of the second image frames consecutively captured by the image sensor,

wherein the processing unit is configured to identify whether the finger displacement exceeds a displacement threshold, and when the finger displacement exceeds the displacement threshold, the calculated physiological characteristic is not outputted by the keyboard module.

14. The display system as claimed in claim **13**, wherein the display device is configured to generate a warning state when the physiological characteristic exceeds a predetermined value.

15. The display system as claimed in claim **13**, wherein the keyboard module further comprises:

a light control unit configured to control the on-states of the first light source and the second light source; wherein

the processing unit is further configured to generate the digital signal according to an operating state of a plurality of keyboard keys of the keyboard module.

16. The display system as claimed in claim **13**, wherein

the processing unit is further configured to calculate another finger displacement according to two of the first image frames and according to two of the second image frames; and

the keyboard module is configured to output the another finger displacement to the display device to accordingly control a cursor displayed by the display device.

17. The display system as claimed in claim **13**, wherein the processing unit is further configured to calculate a heart rate of the user according to a comparison result of comparing at least one pulse threshold with at least one of the first intensity variation and the second intensity variation.

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